Satellite Navigation (SatNav)

Investment Analysis Plan

Mission Need Statement (MNS) #50

Version 3.0 - Final
December 14, 1998

Approved By: _____ Date: _____
Director, Investment Analysis Staff, ASD-400

Federal Aviation Administration
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1.0 INTRODUCTION

The Investment Analysis Plan (IAP) outlines activities that the FAA will conduct in examining various alternatives for possibly transitioning from the current ground-based navigation and landing system to a satellite-based system. Mission Need Statement (MNS) # 50, *Application of Satellite Navigation Capability for Civil Aviation*, describes the current navigation capability shortfalls and their corresponding effect on capacity, safety, and supportability issues. The MNS also addresses the manner in which a differential Global Positioning System (GPS) based system can improve and extend the FAA's ability to provide en route, terminal, CAT I/II/III approach and landing services.

1.1 Background

In January 1998, the FAA's Joint Resource Council (JRC) approved the SatNav Acquisition Program Baselines (APBs) for the Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) programs. Recently, the FAA decided to revisit that decision and consider other alternatives that can meet requirements stated in MNS #50. The Satellite Navigation (SatNav) Investment Analysis Team (IAT) was reconvened under the guidance of the Office of Investment Analysis and Operations Research, ASD-400, with participation from the Associate Administrator for Regulation and Certification (AVR), the Satellite Navigation Integrated Product Team (AND-700), the Associate Administrator for Air Traffic Services (ATS), the Associated Administrator for Airports (ARP), and the Office of System Architecture and Investment Analysis (ASD).

1.2 Scope

The scope for the SatNav Investment Analysis (IA) is outlined below:

- Rebaseline the WAAS and LAAS programs by the end of May 1999.
- Update the SatNav Cost Benefit Analysis (CBA) as agreed in a response to the Government Accounting Office (GAO) report.
- Analyze at least three additional alternatives to current WAAS/LAAS plans including maintaining the current ground-based system (Do nothing alternative).
- Involve key industry proponents and advocates in the development and evaluation of these alternatives and ensure that they believe in the team's objectivity.
- Perform a Lease vs. Buy Study for WAAS Geostationary Satellites and incorporate results in updated Cost Benefit Analysis.
- Consider the results of the Johns Hopkins University (JHU) "GPS Risk Assessment Study" and its implications on GPS backup requirements.
- Consider the implications of the 2nd Civil Frequency and include potential costs in the economic analysis.

1.3 Joint Resources Council Actions

The SatNav IAT will request approval of the SatNav APB at the SatNav JRC Investment Decision meeting and concurrence with maintaining a backup navigation capability, if applicable.

2.0 INVESTMENT ANALYSIS TEAM COMPOSITION

The IAT is comprised of FAA organizations and contract support members from:

- **AAR** - Office of Aviation Research
- **AAS** - Office of Airport Safety and Standards
- **AFS** - Office of Flight Standards Service
- **AIR** - Office of Aircraft Certification Service
- **AND** - Office of Communications, Navigation, and Surveillance Systems
- **ARN** - Office of Air Traffic Systems, Communications, Navigation, and Surveillance
- **ARR** - Office of Requirements and Development
- **ASD** - Office of System Architecture and Investment Analysis

The IAT intends to involve applicable non-FAA organizations.

2.1 FAA Organizations

The FAA members of the IAT by name, organization (core and supporting), and activity are contained in Table 2-1. The MITRE Corporation's subsidiary, the Center for Advanced Aviation Systems Development (CAASD) functions as the FAA's Federally Funded Research and Development Corporation (FFRDC); CAASD's members of the IAT by name, organization (core and supporting), and activity are contained in Table 2-2. The FAA Office of System Architecture & Investment Analysis (ASD) System Engineering and Technical Assistance (SETA) contractor provides high-level system engineering & investment analysis services to the IAT. SETA members are contained in Table 2-3:

Table 2-1. FAA Members Investment Analysis Team

Individual	Organization	Activities
	Core	
Bob Rovinsky	ASD-410	IA Team Lead
Carl McCullough	AND-730	GPS Product Team Lead
Mike Harrison	ASD-100	System Engineering Lead
Bob Fandrich	ARN-100	ATS Requirements Lead
Bruce DeCleene	AIR-130	Sponsor
Hank Cabler	AFS-430	Sponsor
	Supporting	
Millie Butler-Harris	ASD-400	IA Staff
Diana Liang	ASD-430	Benefits Analysis
Dan Hanlon	AND-730	WAAS IPT
Maria DiPasquantonio	AND-730	WAAS IPT
Leo Eldredge	AND-730	WAAS IPT
Dave Peterson	AND-730	WAAS IPT
Ray Swider	AND-730	LAAS IPT
Dave Olsen	ASD-100	System Engineering
Robert Bonanni	AAS-100	Airports
Greg Joyner	AAR-300	International

Table 2-2. FFRDC Members Investment Analysis Team

Individual	Organization	Activities
Mel Zeltser	MITRE/CAASD	MITRE Lead
Kelly Markin	MITRE/CAASD	MITRE Technical POC
Kara MacWilliams	MITRE/CAASD	MITRE IA POC
Jim Reagan	MITRE/CAASD	Technical Staff
Vince Massimini	MITRE/CAASD	Technical Staff
James (JP) Fernow	MITRE/CAASD	Technical Staff

Table 2-3. Contractor Support Members Investment Analysis Team

Name	Company/FAA Org	Name	Company/FAA Org
George Huxhold	SETA/ASD-410	Skip Mead	AMTI/AND-730
Bob Anoll	SETA/ASD-100	Phil Baker	AIR-130 Contractor
Ron Hinkel	SETA/ASD-100	Don Markel	ECARS/ARR-100
Mark Kipperman	SETA/ASD-410	Don Mixon	ECARS/ARR-100
David Schall	SETA/ASD-100	Gary Solom	TAC/AND-730
Anne Yablonski	SETA/ASD-410	Chris Webb	AMTI/WAAS TAC
Michael Gormally	SETA/ASD-410	Mark Fuhrmann	AMTI/AND-730
David Yancey	SETA/ASD-410		

2.2 NON-FAA ORGANIZATIONS

As necessary and appropriate, the IAT may choose to bring other user organizations and industry representatives into its deliberations. They may be invited to participate in IAT meetings to comment on various issues and to receive updates on the IAT's progress. The views of these organizations will be considered, along with other factors, and will assist the IAT in shaping its recommendation to the JRC. Organizations currently identified as interested parties are contained in Table 2-4:

Table 2-4. Non-FAA Organizations

Non-FAA Organizations
National Air Traffic Controllers Association (NATCA)
Professional Airways Systems Specialists (PASS)
Air Transport Association (ATA)
Cargo Airline Association (CAA)
Aircraft Owners & Pilots Association (AOPA)
Air Line Pilots Association (ALPA)
National Business Aircraft Association (NBAA)
International Civil Aeronautics Organization (ICAO)
Helicopter Association International (HAI)
Airports Council International
American Association of Airport Executives
Regional Airline Association (RAA)
Aircraft Manufacturers

In particular, the IAT will be developing proponent input through the RTCA process.

3.0 NAVIGATION REQUIREMENTS

The SatNav IAT has reviewed current FAA mission need statements and requirements documents associated with navigation and has determined that these are too specific to SatNav to be used unequivocally in this analysis. Thus, the IAT formed a Requirements Subgroup, under the leadership of AVR -- the sponsor -- to develop the necessary requirements that future architectures must meet to replace the current all ground-based navigation capability in the National Airspace System (NAS). That subgroup will determine the specific technical, operational, and architecture performance requirements that each alternative will need to meet.

3.1 General Requirements

The FAA has the statutory authority to establish, operate and maintain the required navigation capability for all phases of flight. The flight phases include oceanic, enroute, terminal, approach/departure, and landing. For the FAA to accomplish its mission, the future navigation capability must be provided with the appropriate accuracy, integrity, and reliability to support all-weather operations in each phase of flight.

Also, any new navigation capability introduced must adequately support the needed capacity enhancements of the National Airspace System (NAS) and its Oceanic or international interfaces. That is, the new capability must not only meet the forecast of near-term growth of flight operations (through 2010 - 2015) but also be capable of cost-effective selective expansion to meet further anticipated increased demands in usage in the long-term.

3.2 Specific Technical Performance Requirements

Initially, the Requirements Subgroup will base requirements on the current draft Standards and Recommended Practices (SARPS) from the International Civil Aviation Organization (ICAO) Global Navigational Satellite System Program (GNSSP) that clearly links National Airspace Systems (NAS) requirements to the world navigation system.

4.0 ALTERNATIVES

The SatNav program is a large investment and will shape the next several decades for civil aviation. The IAT is committed to considering a representative range of alternatives to SatNav. To ensure that all proponent interests are considered, the IAT team will obtain proponent input in development of technical alternatives. While all possible alternatives will not be evaluated, the team intends to evaluate a representative range.

In defining alternatives, the team will follow two guidelines:

1. FAA currently provides certain navigation services (e.g. VHF Omni-directional Range (VOR)/ Distance Measuring Equipment (DME), Non-directional Beacon (NDB), Instrument Landing System (ILS), etc).
2. FAA currently requires users to equip with certain navigation services for specific operations through the operating rules.

For the user community, it is essential to distinguish mandatory equipage from optional equipage. This distinction acknowledges an important role that the user community plays in choosing to equip with a

navigation system. It also forces the investment analysis to recognize factors that govern aircraft equipage and will help prevent the IAT from making an invalid assumption.

The investment analysis will consider navigation architecture alternatives consisting of selected combinations of satellite and non-satellite navigation elements. Navigation architecture alternatives can be considered to be elements of a matrix whose rows are satellite navigation elements and whose columns are non-satellite elements. A "down-select" process will identify the most promising alternatives for a subsequent detailed cost and benefit analysis.

Satellite navigation elements include WAAS, or modified versions of WAAS and LAAS, or modified versions of LAAS. Tables 4-1 and 4-2 provide examples of the versions of WAAS and LAAS that may be judged worthy of further consideration.

Table 4-1. Possible Versions of WAAS to Consider

	Number of Geostationary satellites	Number of WAAS Reference Stations (WRSs)	Number of WAAS Master Stations (WMSs)	Hardware and Software
WAAS Phase 3 (the current plan, meeting all requirements of the WAAS Specification, FAA-E-2892C)	4-5 total	48 in U.S. 20 in Canada and Mexico	3-4 total	O&M upgrades; Security upgrades; Algorithm enhancements; and Safety architecture upgrades
WAAS Phase 1.5 (Designed to provide improved precision approach coverage with availability for NPA and PA reduced below FAA-E-2892C)	3 total	25 in U.S. 20 in Canada and Mexico	3-4 total	O&M upgrades; Security upgrades; Algorithm enhancements
WAAS Phase 1.25 (designed to support en route through NPA only with availability reduced below FAA-E-2892C)	3 total	10-12 total.	3-4 total	O&M upgrades; Security upgrades
No WAAS	0	0	0	—

Examples of LAAS alternatives are shown in the table below. The question of whether or not to use LAAS, ILS, or a mix of LAASs and ILSs for CAT II and CAT III is independent of whether or not LAAS is used for CAT I.

Table 4-2. Possible Versions of LAAS to Consider

	Number of LAAS installations
LAAS (current plan) for CAT I not served by WAAS and all CAT II/III	143 airports
LAAS for all CAT I	Up to 650 airports, or 800 if additional airports qualifying for CAT I are included
LAAS for all CAT I and at least some CAT II/III	Up to 650 airports, or 800 if additional qualifying airports are included
Extended Local Area Augmentation System (ELAAS). In this alternative, ground stations would provide backup guidance for not only precision approach but also en route and terminal guidance in a wider area. Stations would broadcast corrections at a higher power, supporting reception up to 100 miles from each station.	More than 650
No LAAS	

Non-satellite elements may include, but are not limited to, one or more of the following:

- A subset of current VORs, DMEs, NDBs, and/or ILSs
- Continued support of LORAN-C, which is currently planned to be upgraded to support service into the next century
- GPS/inertial system integration (various types exist; some are currently in use while others are in early developmental stages)
- Modified Traffic Information System (TIS) -- a concept in which aircraft positions, derived from secondary surveillance radar, would be transmitted to aircraft in the radar's coverage area.

4.1 Investment Analysis Approach

The SatNav IA will be conducted in accordance with the FAA's Acquisition Management System and the Investment Analysis Process Guidelines. IAT activities will include the following: a review of the navigation and satellite navigation requirements, an economic analysis of FAA and user costs and benefits, a risk assessment of alternatives, a NAS Architecture impact assessment, an affordability assessment, development of an acquisition program baseline, and required documentation. The requirements document will be reviewed and updated if necessary. The technical and operational Alternative Analysis will be the responsibility of MITRE's CAASD organization with participation of the IAT. The Alternative Analysis will incorporate pertinent data from an ongoing Department of Defense (DoD)/Department of Transportation (DoT) subgroup for the Aeronautical Radio Navigation Spectrum (ARNS) civil frequency, the AND-700 Lease vs. Buy study, and the Johns Hopkins University (JHU) GPS Risk Assessment study. The results of the Alternative Analysis will propose a set of alternatives for transitioning to satellite-based navigation. MITRE will publish an alternative analysis report for incorporation into the IAR.

The most important task confronting the team is to build a credible "business case" for whatever alternative it recommends to FAA's senior managers. Such a business case will need to be credible to national airspace users both within and outside the agency, and will require considerable input from both industry and user groups. Underlying this business case is an economic analysis, including a baseline of FAA and user costs, benefits, and risks, which will be led by the Investment Analysis Staff (ASD-400)

with the assistance of the entire team.

Key proponents will be involved and briefed at regular intervals throughout this process, as will the Office of Inspector General (OIG) (and perhaps GAO). Upon completion of the Alternatives Analysis and the Economic Analysis, a Decision Analysis will be conducted to evaluate alternatives and determine a recommended solution. Decision criteria are listed in Section 4.1.2 Decision Criteria.

The Affordability Assessment will then be constructed and will consist of submitting an APB for the recommended alternative to the Systems Engineering and Operations Analyst Team (SEOAT) to determine the alternative's affordability with respect to the Facilities and Equipment (F&E) budget. Every effort will be made to engage the Operations Research Management Team (ORMT) and Research Engineering & Development (RE&D) Team for O&M and RE&D budget compatibility.

The Investment Analysis Report (IAR) will document results from the SatNav Investment Analysis activities and will recommend to the JRC a SatNav Acquisition Program Baseline. During the course of the IA, the team will submit progress reports to FAA Senior Managers. These reports will be timed to allow the agency to respond to the JHU GPS Risk Assessment study and agency testimony during the March-April budget hearings.

This approach will be implemented through the creation of subgroups that will lead various activities required to carry out the plan. The IAT has identified leads for the following subgroups:

- Requirements (AIR-130 / AFS-430)
- Benefits (ASD-430)
- Cost (ASD-410)
- Alternatives (CAASD)
- Transition Team (AIR-130 / AFS-430 / ASD-100 / ARN-100 / AND-730)

4.1.1 Assumptions

Several assumptions, constraints, and conditions will guide the investment analysis. Three categories have been established to group the assumptions: General, WAAS, LAAS, and Backup:

General Assumptions

- A period of approximately ten (10) years will be necessary to fully transition from the current all ground-based navigation system of today to any new navigation capability.
- At least half and potentially all ground based navigation and Category I ILS landing systems will be decommissioned by the end of the year 2010.
- Independent surveillance capabilities will continue to be available for the foreseeable future, and the vast majority of Instrument Flight Rules (IFR) aircraft will carry transponders.
- A 15-year life cycle will be used for evaluation of the costs and benefits for all alternatives. Note: This may cause difficulty, because of disparity with schedules (WAAS, LAAS, 2nd Civil Frequency, etc.).
- Sunk costs incurred prior to FY00 for each alternative will not be considered in the overall CBA.
- The study will consider military and civilian aviation.

WAAS Assumptions

- WAAS reference stations (WRSs) will also be sited in Canada and Mexico at no additional cost to the FAA.
- GPS Selective Availability will be turned off by 2006.

- The DOD will fund and manage GPS space segment and continue to provide GPS service beyond the year 2016.
- Twenty percent of air carriers will equip with WAAS in 2001; the remaining eighty percent will equip with WAAS when they can equip with LAAS.
- Aviation and non-Aviation related benefits will be examined, and non-Aviation benefits will be expressed qualitatively.

LAAS Assumptions

- Any new qualifiers for CAT II/III will require analysis of lighting and Runway Visual Range (RVR) costs for runways.
- One LAAS will be installed at each qualifying airport.
- Major components of the LAAS & WAAS systems will be replaced every six years. Other equipment will be replaced less frequently or not at all during the life cycle of the system.

Backup Assumptions

- For every scenario that includes decommissioning, both the costs of decommissioning and the cost of avoidance (O&M) will be included in the CBA, but not in the SatNav program baseline.
- Backup capabilities cannot be susceptible to the same failure cause as the primary system.
- Backup capabilities should mitigate the failures in the primary system.
- Backup will not be needed for Oceanic areas.

4.1.2 Decision Criteria

A standard set of Decision Criteria will be used for evaluating all proposed alternatives. The decision criteria fall into four major categories:

- **Mission Effectiveness**. This major category determines whether the alternative meets the requirements for NAS Navigation Services for all phases of flight.
- **Risk**. This major category determines the risk associated with implementing the alternative within the NAS.
- **Return on Investment**. This major category includes CBA, total life cycle costs, and the ability to secure funding from Congress.
- **Strategic Alignment**. This major category determines the impact on FAA/DoT activities and strategies, GPS policies, international constraints, and frequency spectrum issues.

4.2 Lease vs. Buy

Congress has mandated that the FAA conduct a Lease vs. Buy analysis for WAAS Geostationary satellite option to estimate whether leasing or buying is the most economically feasible option for the FAA. The IAT will perform the mandated Lease vs. Buy Study and incorporate the results into the cost estimation portion of the Economic Analysis.

4.3 Issues

The major issues underlying this analysis include the following:

- The existing Requirements Document needs to be revalidated and possibly revised with respect to the Mission Need statement and concepts of operation.
- The IAT must gain involvement from proponents in a manner that does not impede progress yet

contribute to credibility in the analysis.

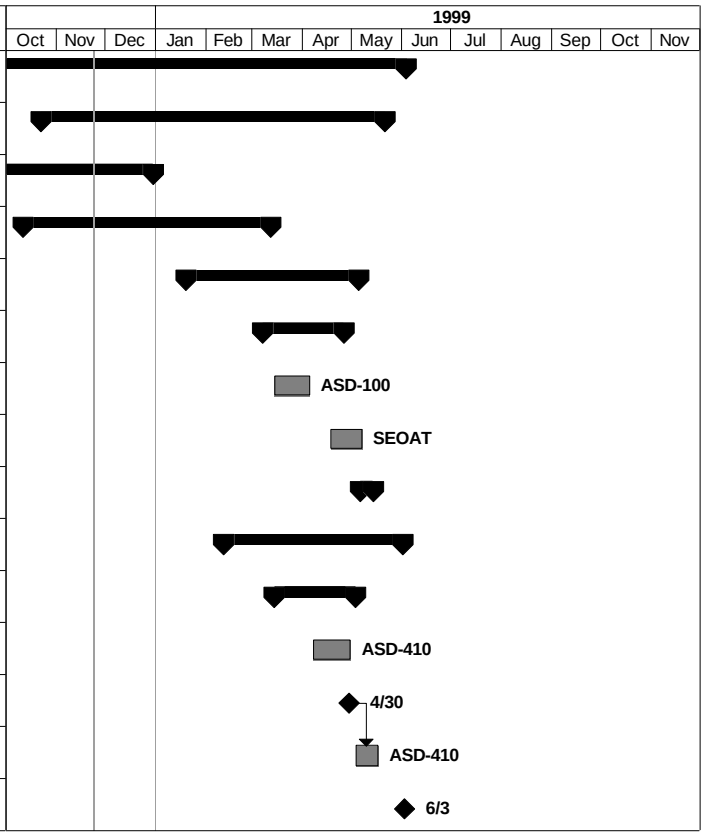
- Coordination and integration of the JHU GPS Risk Assessment Study in the IA process.
- For 2nd civil frequency, is ARNS protection required for all valid options?
- Should we consider DoD GPS modernization plans?
- How do we treat threats (e.g., jamming) to existing ground-based NAVAIDs?

5.0 SCHEDULE

Shown in Table 5-1 are activities and estimated completion dates for activities and products that will assist in the completion of the Investment Analysis. The goal of these combined efforts is an approved JRC program funding level for implementation of SatNav. This schedule is subject to modification as the Investment Analysis progresses. Initial responsibilities assigned for the SatNav Investment Analysis activities are shown on Figure 5.1:

Figure 5-1. Gantt Chart of Activities and Products

ID	Task Name	Start	Finish
1	**Manage the SatNav Effort**	10/2/98	6/3/99
2	**Involve Stakeholders**	10/23/98	5/21/99
12	**Alternatives Development**	10/2/98	12/30/98
27	**Alternatives Analysis**	10/12/98	3/12/99
38	**Economic Analysis**	1/20/99	5/5/99
47	**Risk Analysis Assessment**	3/8/99	4/26/99
53	**Architecture Assessment**	3/15/99	4/5/99
54	**Affordability Assessment**	4/19/99	5/7/99
55	**Decision Analysis**	5/7/99	5/14/99
57	**Develop IAR**	2/12/99	6/1/99
68	**Develop APB**	3/15/99	5/3/99
71	**Develop JRC Briefing**	4/8/99	4/30/99
72	**Brief Senior Managers**	4/30/99	5/3/99
73	**Brief Associates**	5/4/99	5/17/99
74	**JRC**	6/3/99	6/3/99



6.0 ASSIGNMENT OF ROLES AND RESPONSIBILITIES

Table 6-1 below shows the primary lead for major activities and products associated with the SatNav IAP:

Table 6-1 Organizational Responsibilities for IA Activities and Products

Activity/Product	Lead
Investment Analysis Team Commissioned	Associates
Investment Analysis Plan Approved	ASD-400
Managers Kickoff Meeting	ASD-400
Review IAP with Associates	ASD-400
Proponent Input for Alternatives Development	ASD-410
FAA Management and Proponent Buy-In	ASD-100, ASD-400, AND-700, ATS, and AVR
Baseline Requirements	AIR/AFS
Select Alternatives for Analysis	ASD-410
Technical and Operational Analysis of Alternatives	MITRE
Analysis of Alternatives	MITRE
Review Alternative Analysis Plan with MITRE	Associates
Brief Proponents on Alternatives Analysis	ASD-410
Share Alternatives for Analysis with Associates	ASD-410
Technical Analysis Report Approved	MITRE
Benefits Analysis	ASD-410/SETA
Risk Analysis	SETA
Cost Analysis	SETA
Lease vs. Buy Study	ASD-410/ASD-730
Calculate Net Present Value and Benefit/Cost	SETA
Affordability Assessment	SEOAT
Decision Analysis	ASD-410
Final APB	ASD-410
Brief ASD-1/100	ASD-410
Brief Associates	ASD-410
Involve Satellite Operational Implementation Team (SOIT) /ICAO	ASD-410
Final Draft IAR to Management	ASD-410
IAR Signed	ASD-410
JRC	ASD-410
Transition Plan	AIR/AFS

ASD-100 -- Will provide architectural analysis and evaluation for each of the candidate solutions. ASD-140 will provide systems engineering expertise and provide technical assistance to the alternative analysis process.

ASD-400 -- Will provide analytical expertise to develop the Alternative Analysis and data to be provided to the SEOAT and SAT for Affordability Analysis. ASD-400 will assist AND-730 in the preparation of the Acquisition Program Baselines (APB). ASD-400 will also prepare the IAP, IAR, and brief the JRC on behalf of the IAT.

AVR (AFS-400 and AIR-130) -- The sponsoring organizations will initiate review of navigation and satellite navigation requirements. Also, responsibility for preparation and approval of the initial final requirements document.

AND-700 -- Will provide technical knowledge of navigation, ILS, GPS, WAAS, and LAAS in particular. AND-730 will assist the sponsor in developing the requirement documentation and prepare the APBs with ASD-400.

ARS/ARR-100 -- Although not the sponsoring organization for this MNS, ARR is included in the IAT to coordinate information and expertise from ATS resources and to validate O&M costs of the alternatives.

AAS-100 -- Airports will provide a better understanding of the consequences of each alternative to airport authorities.

MITRE -- Will lead the technical and operational alternative analysis with participation from the IAT. Also, participate in all phases of the investment analysis.

SETA -- Will lead the economic analysis and risk analysis with participation from the IAT.

Other Organizations -- A variety of other organizations are participating in order to provide technical expertise and assistance in collecting data. The team is currently developing contacts within the American Association of Airport Executives (AAAE) and the Air Transport Association (ATA) to obtain a better understanding of the user perspective.

7.0 RESOURCES REQUIRED

- $200K has been made available to ASD for conducting a benefits analysis.
- MITRE/CAASD resources have been reprioritized to assist in this effort.
- SETA resources, supporting both ASD-100 & 400, have been identified to support this Investment Analysis.

Bibliography

1. Acquisition Management System Investment Analysis Process Guidelines; January 22, 1997; Federal Aviation Administration, Office of Systems Architecture and Program Evaluation (ASD), Steve Zaidman, Director

2. Current draft of SARPS from the ICAO GNSSP

3. Government Accounting Office (GAO) report "Report to Congress, Wide Area Augmentation System (WAAS) Report on Program Status, Management, and Satellite Communications", U.S. Department of Transportation, Federal Aviation Administration, January 1998.

4. Mission Need Statement #050, Application of Satellite navigation Capability for Civil Aviation Link; October 23, 1992; Approved by Transportation Systems Acquisition Review Council.

5. "NATIONAL AIRSPACE SYSTEM Status of Wide Area Augmentation System Project", United States General Accounting Office Report to Congressional Requesters, GAO, April 1998, GAO/RCED-98-79.

6. Satellite Navigation Investment Analysis Report (IAR), January 1998.

7. The Redundant Radionavigation Service in the National Airspace System, November 1998.